

Epidemiology of paediatric injury

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SUMMARY

Thousands of young lives are lost every year as a result of accidents, and trauma remains the number one cause of paediatric death. There is a pattern and regularity to children's injury: boys are more often victims than the girls, most injuries occur during the summer months, the pedestrian child has usually been the victim of a road traffic accident (RTA) and, in 75% of these cases, has suffered head injury. The research into paediatric trauma is still very young. For instance, socio-economic and ethnic factors play a significant role in the statistics of accidental death. In order to take effective preventative measures more factors must be determined.

INTRODUCTION

Every parent fears the dangers that children face as they move through childhood. When perusing the available statistics on paediatric injuries from accidents, one may well wonder how any children escape the calamity inherent in the jungle gym, household mishaps, the park swing, the first unsupervised bus journey and the dangers of city traffic. In addition, every parent in well acquainted with those sometimes intensely anxious moments associated with a youngster's acquisition of a driver's license. Yet, most children pass through infancy, childhood and even adolescence without serious trauma.

However, accidents remain the main cause of death of children between the ages of 1 and 14 years. In fact, in most of the world, accidents are the main cause of death of males up to the age of 35 years. In the USA, the annual death toll from accidents of between 8000 and 10 000 children speaks for itself. Distinctive patterns of paediatric injuries are now emerging as the result of recent epidemiological studies.^{2–4}

ACCIDENTS IN INFANCY AND EARLY CHILDHOOD

Any mishap befalling infants can be blamed on the adult care-giver. Later, as the child learns to walk, he or she discovers endless numbers of ways to come to harm; the majority of early childhood injuries, however, are so-called 'minor'.

Minor injuries

According to the National Pediatric Trauma Registry (Boston) minor injury is defined as that given an Injury Severity Score (ISS) of less than 9. Some 80% of the admissions at Children's Memorial Hospital, Chicago (CMH), were for minor injuries: burns, abrasions, lacerations and long bone fractures occurring most frequently. Minor burns, i.e., those that affect less than 10% of the body surface, represented less than 1% of emergency room (ER) treatments. For example, from 1 September 1992 to 31 August 1993, 36 000 children were seen for emergency treatment at CMH. Of this number, 205 (0.6%) were burn patients.

In Britain, there are an estimated 15 000 minor burn accidents annually which require professional help. These accidents occur primarily in 1- to 2-year-old children who have been scalded by hot liquids or who have come in to contact with a hot iron. Toddlers can pull boiling pots off the stove or excessive heat under a boiling pan can cause liquids to boil over, resulting in immersion burns. Children over 3 years of age become interested in matches and flammable liquids, which can cause different, and usually more serious, injuries. Boys and girls are equally affected.

Ninety per cent of accidents occur in the home. A glass container handled or carried by a running child may break, causing extensive cuts, tendon, nerve or vascular injury.^{5–8}

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Foreign body aspiration

In the USA in 1991, 250 children under 4 years of age died as a result of foreign body aspiration⁴ and UK statistics report 50–60 deaths annually.⁸ Often toddlers' newly found freedom of movement prompts them to grab any object that strikes their fancy and an attempt to examine it quickly often means the object ends up in the mouth. Absence of molar teeth at this age does not allow the child to grind an object and immature neuro-muscular coordination of the pharynx often leads to the aspiration of the contents of the mouth. The most frequent cause of food asphyxiation in this age group in the USA is sliced hot dogs. Nuts, beans, popcorn and pieces of raw vegetable are commonly lodged in the tracheobronchial tree, usually in the right lower bronchus.

The US National Safety Council reports a annual steady decline in the last 4 years in the number of deaths among children who have aspirated foreign objects. The credit for this decline must go to American physicians who have conducted a vigorous preventive campaign and who are constantly attempting to educate parents and medical care providers and to influence manufacturers to make toys radio-opaque and appropriately shaped and sized.^{9–11}

Motor vehicle accidents (MVAs)

General statistics about fatal motor vehicle accidents involving infants and child passengers generally show quite different circumstances than those involving adults.¹² Data from Washington State between 1977 and 1979 show that most crashes involving children happen on a weekday and during daylight hours, with fair weather and a dry road surface. The same data reveal that eight out of 39 fatalities (20%) occurred while a child was held in the lap: in seven of these accidents, the person holding the child survived. Five of the children were crushed by the body weight of the person on whose lap they were sitting. The younger the children the more likely they are to die in such accidents and those below the age of 1 year are particularly vulnerable.^{13,14}

One study conducted in the state of Michigan found that 42% of the population sampled had travelled with a child on the driver's lap. This practice is illegal in both the USA and in Britain, yet it continues to be common occurrence.¹⁵

The leading cause of paediatric injury and death

is RTAs. Data from the US National Safety Council does indicate a steady decrease in mortality in such accidents for those aged between 1 and 12 years of age, however, there has been a rise in death rates among teenager divers.^{4,5} In 60% of fatal accidents, the victim is a pedestrian child. Child cyclists and car occupants are killed less frequently; they represent between 14 and 16% of fatalities.^{5,16–18} The majority of deaths of pedestrian children occur when the children cross the road or enter the street between intersections. In 1990, in the USA, 51% of unrestrained occupants in cars involved in fatal collisions were killed and 27% of restrained occupants died. Early in 1992, some 40 states in the USA enacted seat-belt laws and 10 of these states provided primary enforcement. In the 30 states with secondary enforcement, non-compliance with seat-belt regulations results in a fine only when the vehicle is stopped for some other infringement.⁴ Front and rear seat-belts are now standard on all cars manufactured in the USA and in the UK since October 1986.¹⁹

All 50 states of the USA and the District of Columbia have mandatory child safety-seat laws. By 1990, use of car safety-seats for children was estimated at 60% and by 1993 that figure had risen to 81%. The increase in the use of car safety-seats for children between 1 and 4 years of age was even more significant; this figure rose from 38% safety-seat usage for this age group in 1983 to 84% safety-seat usage in 1990. Despite these increases, 71% of children below the age of 5 years who were killed in 1990 in car accidents were unrestrained.¹⁹

Bicycle injuries

In 1991 Americans owned an estimated 105 million bicycles, and in that year 340 children of 14 years or under died as a result of cycling accidents, comprising 42% of all cycling accident victims. That percentage has remained almost unchanged since 1940. In 1991 some 13 000 children were injured while cycling in the USA, more than 11 000 of them on city streets. These data were compiled by the US National Safety Council based on reports from state traffic authorities.^{4,21} In one comparison of the data collection in North Carolina of emergency rooms vs. state police traffic records, only 10% of cycling accidents reported in emergency room records were also found in state police files.¹⁸ State police files almost exclusively recorded accidents involving motor vehicles. If these data can be extrapolated to the rest of the USA the possibility of gross under

reporting of cycling accident-related injuries must be considered. Children from 10–14 years of age comprise the largest group who are in jeopardy. A striking finding for 9- to 14-year-old cyclists is that 9 out of 10 of the injured (90%) are boys. The reason for this phenomenon, which is also evident for other accidents, may be the different rate at which motor coordination and maturity develop in boys compared with girls, or the more daring attitude often exhibited by boys. The singular exception to this statistic is in UK equestrian accidents in which the injury rate is higher for girls than boys.^{5,16,22–24} The increasing popularity of high performance bicycles combined with the daredevil attitude characteristic of some boys this age creates ample opportunity for mishaps. Thirty per cent of accidents occur on city streets at non-intersection locations and a further 17%, off a driveway.^{4,21} Motor vehicles were involved in 17% of all bicycle accidents, but for those accidents involving riders over 15 years of age, the percentage of motor vehicles involved rose to 29%.^{4–21} Most paediatric bicycle fatalities usually occur because a collision with a motor vehicle results in severe head injury to the child which is responsible for 80% of fatalities.^{25,26} Cycling helmet use reduces the risk of head and brain injury by 80, however, helmet use is estimated to be less than 5% among child cyclists in the USA.^{27–30} The Australian state of Victoria waged a decade-long campaign of mass media publicity, educational programmes, and financial incentives before enacting a law in 1989 requiring that an approved safety-helmet be worn by cyclists. There was an estimated 50% decline in the number of cyclists killed in the following year.^{26,31}

Sports injuries

Sports like baseball, basketball, football and cycling engage 15–50 million active followers in the USA. Each activity results in approximately half a million injuries annually: basketball, 640 759 injuries and cycling, 580 119 in 1991. Other sports with numbers of participants at approximately 10 million are: soccer, swimming, and volleyball, each responsible for more than 100 000 injuries annually. Horse riding and roller skating were the cause of fewer than 100 000 emergency department attendance. Roller skating and roller blading, which have recently become popular in USA cities among all ages, result in typical limb injuries: abrasions and wrist and knee fracture injuries. Compiled data regarding children injured during participation in sports are scarce, with the exception of cycling injuries.^{4,32}

Regardless of the type of sports accident analysed, boys are more likely to be injured than girls. The male-to-female accident ratio varies from 4:1 to 1.6:1, with the difference more pronounced in children between 5 and 9 years of age.

Firearms injury

Penetrating injuries affect approximately 10% of the paediatric trauma population^{33,34} and stab wounds comprise 3% of this group. Firearms, however, are the most lethal cause of injury in the USA.^{32,35,36} In an analysis of 4615 paediatric trauma patients treated in Pennsylvania, gunshot wounds were the caused fatality in: 45.5% of children aged between 0 and 4 years of age; 15.8% of those aged between 5 and 9 years of age; and 20% of those between 10 and 14 years of age.³⁷

Each year, firearms play a role in the death of over 40 000 Americans. Only 1400 of those deaths are stated as accidental. In 1987, in the USA, there were over 12 000 homicides caused by firearms. In 1990 almost 5000 young people age between 1 and 19 years of age died of gunshot wounds.^{36–38} In contrast, during that same year in Britain, firearms were involved in a total of 46 deaths.⁷ These statistics reflect what is visible on the front pages of the daily newspapers in New York, Los Angeles or Chicago, for example escalating gang wars and drive-by shootings often leave school children dead. In 1988, 13 children with gunshot wounds were admitted to Children's Memorial Hospital in Chicago; in 1992, the number rose to 32.^{36–38} According to the *Chicago Sun-Times* and the *Chicago Tribune*, the firearms death count in 1992 for children in Chicago was 57 and 3 as of 10 October 1993, the death count was 55 for the year. It could be speculated that the reason behind this increase in violence in Chicago lies in gang war dynamics and changes in the drug trade, however, no research or other data exist to confirm such speculation. There is a steady nationwide increase in the death toll from firearms and the USA still lacks effective gun control legislation.^{36,38}

Head and cervical spine injury

Children younger than 15 years of age have a 2.5% mortality rate secondary to head injury vs. 10.4% for adults. However the highest paediatric mortality rate, 6.2%, is found among 1- and 2-year-olds. Some researchers indicate age as an important factor in survival after head trauma.^{33,39–41}

Because of their size and proportions, children have different injury patterns to adults. The anatomical and pathophysiological differences in children are as follows:

- (1) head-to-body ratio is greater;
- (2) cranial bones are thinner, offering less protection to the contents of cranial vault;
- (3) brain cells are less myelinated (less mature) and therefore are more vulnerable;
- (4) increased intracranial pressure occurs more often (80 vs. 50% in adults) and presents as 'malignant brain edema'; and
- (5) global injury (diffuse cerebral swelling) dominates (50 vs. 30% in adults) over mass lesion.

In most populations of children with multiple injuries, 80% are diagnosed with head trauma. For example, of 99 patients admitted to Children's Memorial Hospital between 1985 and 1988 with multiple organ injuries, 75% suffered head trauma. In adults with multiple organ injuries, approximately 50% suffered head trauma.^{24,42,43}

In this grim picture there is an optimistic message: only one out of 10 head injuries is serious; the remaining nine are mild, as measured by the Glasgow Coma Scale (GCS). Spinal injury in children is rare because of the greater flexibility and mobility of their tissues, with the exception of children under 4 years of age and those with Down's syndrome.⁴⁴ The paediatric population is subject to cervical injuries now emerging with the common use of child restraining devices and child forward-facing car-seats.^{15,20,45-49}

Five cases of high cervical spine fractures have been reported in children under 2 years of age involved in head-on car collisions. As children have a high centre of gravity, sudden deceleration causes the restrained child to be propelled, missile-like, head-first into the dashboard, windscreen or the back of the front seat.

When a child is restrained, abrupt stops cause hyperflexion of the cervical spine with lax ligaments and weak neck musculature. The horizontal facet joints of C₁-C₃ and the incomplete ossification of C₁ and C₂ may result in odontoid epiphysiolysis or vertebral fracture.^{45,50,51} The percentage of spinal cord injury (SCI) in the paediatric population in the USA ranges between 0.7% and 14% with a male to female ratio of 4:1.⁵² One recent study indicated that motor vehicle accidents and sports or play accidents accounted equally for 36% of children's spinal injuries. Both involvement in a vehicular

accident and complaint of neck pain correctly identified the potential injury.^{52,53}

Abdominal and thoracic injuries

Head, abdominal, and chest injuries including those that result from gunshot wounds account for the most disabilities and the majority of deaths in injured children.

Abdominal trauma is the second most frequent cause of death in the injured child (25%). The organs which are injured most commonly are the liver and spleen. Parenchymal organ injuries in children (liver, spleen) are responsible for death in 30% of cases and in 10% of adult cases. The reason for the difference may be in the child's anatomy, different splenic capsule or in the mechanism of injury. Rupture of a hollow viscus occurs relatively infrequently in accident victims.^{54,55}

Solid organ injury in a child creates a diagnostic challenge because of the very young patients inability to communicate symptoms and because the external signs of trauma may be trivial. Thin abdominal and thoracic walls without strong muscular protection offer scant natural defense to the intra-abdominal and intrathoracic organs of children. Paediatric chest injury is, in the majority of cases, caused by blunt trauma. In the case of minimal or no external thoracic trauma, parenchymal injury to the lungs and heart may still be severe. In fact, in approximately 53% of cases, the lung is the most commonly injured organ. In one analysis, 53% of pulmonary contusions occurred without rib fracture.³² Fractures of the first ribs, although rare, may indicate the likelihood of injury to great vessels. Pneumothorax is a common sequelae of multiple rib fractures. Only a small percentage of thoracic injuries in children will require operative intervention.^{33,34,56,57}

Environmental and social factors contributing to injuries

In the USA and other countries of a temperate climate zone a periodic surge of accidents occur with good weather and increased daylight hours. The peak months for accidents involving children and young people are June to August. Statistics for May to November show an above average rise in accidental deaths and in the months of December to April, the number of accidental deaths declines. Analysis of a paediatric trauma population

in Birmingham, UK, showed a predominance of RTA injuries among children from infancy to 5 years of age during the summer months while accidents involving falls and burns dominated in autumn and winter.⁵⁸ Children aged between 6 and 10 years old are the most vulnerable group for all types of accidents during the summer months and, studies show that 50% of these accidents occur between 16.00 and 19.00 h.^{5,32,58,59} Summer-time, a child's delight, represents a serious worry and an enormous increase in workload for emergency medical services, emergency room personnel and trauma teams. Between June and September, the medical community must be on the alert.^{6,60}

An estimated 30% of all accidents involving children occur at home or within a short distance of home.⁴ Of the total of number home accidents in 1990 in the USA 7 000 000 of the victims were children and injuries resulted in the deaths of 3000 children aged between 1 and 14 years. In practical terms, there is a home accident every 10 s and two people die every hour as a result of these accidents.

Trauma, in agricultural settings, which poses an occupational hazard for adults, does not spare children. In 1986, some 7800 children were involved in farming accidents in the USA, and 300 of them were left permanently disabled.^{61,62}

Many injuries are sustained as a result of falls which can be as serious as a fall from a 10-story building or as ordinary as a tumble off a bunk-bed. American urban dwellings create uniquely dangerous circumstances for falls from heights. Severe injuries can result from falls from between 5 and 40 feet. Falls from less than 10 feet are less likely to produce a life-threatening injury.^{58,63–66} In Chicago, falls were the main cause of urban accidental death among children in 1989 (Reynolds, personal communication). City regulations demanding protective window grills on upper stories could be an initial step toward prevention.

In several states, however, (Alabama, Illinois, Maine, Maryland, New York and a few others) fires were the leading cause of paediatric deaths and. In Florida, drowning was the leading cause of death.⁴

Fires, drownings in home pools and bathtubs and smothering by bedclothes or plastic wraps claim most victims among infants and children under 4 years of age. Although no specific cause of death at home has been eradicated dramatically, during the period 1991–93 there was no increase in the overall death rate in any of the categories.

It is said that unfortunate accidents more often

befall the poor.⁵ A study was conducted among care-givers of young children (6 years old) who enrolled in an inner-city paediatric clinic for those on public assistance or without health insurance. The study indicated a high frequency of accidents (37% of households) and poor supervision of children. In 80% of these homes, neither hazardous substances, such as cleaning supplies, fuels or medicines, nor sharp objects, such as knives and scissors, were stored securely and were easily accessible. Moreover, 95% of the children younger than 5 years included in the study were left alone in the bathtub and 2% of them even swam unsupervised. Environmental conditions permitting, exposure to injury by burns, falls and firearms or unsafe travel conditions (i.e. lack of or use of inappropriate restraints) was common.^{59,67,68} In a study in Maine, children from low-income families were found to be five times more likely to die in a fire than other children and, in general, had a death rate 2.6 times higher than that at children from families with average and above incomes.²² In a study of the poor community in Chicago, respondents were poorly informed about safety practices. Only 14% named their experience and reading as sources of safety information and in 50% of cases, grandparents were the guardians of the children's safety.⁶⁹ This indicates a dramatic need for well designed, effective injury preventive programmes targeted on high-risk populations.

Child abuse

It is possible that more than one million children are abused each year in the USA.^{5,32,71,72} Two hallmarks of the battered child syndrome are: (1) a history that is inconsistent with clinical findings; and (2), a delay in seeking medical care.

Child abuse, as a clinical syndrome, has only been recognized since 1962. Today, it would be difficult to overestimate its occurrence. The incidence of abuse in the population under 6 years of age is estimated to be between 10 and 15% of all children in the USA. Invariably the patient's history is inaccurate, difficult to obtain or evasive. The majority of abused children are under than 2 years old and have evidence of previous injuries: burn scars, bruises, bone or rib fractures in different stages of healing, chronic subdural haematomas, subgaleal or intra-ocular haematomas, retinal detachment or peri-orbital ecchymosis. One study indicated that children are abused frequently by the mother or other family member.⁷¹ Signs of general

neglect, anaemia, and malnutrition are also often present. Poverty, illegitimacy, a mother under 17 years of age or a broken home featured frequently in the scenario. Soft tissue injury is the most common reason for an emergency hospital visit, however head injury followed by abdominal injury are the leading causes of death among abused children. When treating the injured child, the physician must always entertain the possibility of abuse.

Efforts to improve awareness of child abuse in the medical community must be increased. By recognizing abuse when children are presented, physicians may be able to protect the victim from future attacks.

The range of paediatric injuries involves medical, social and ethical considerations. The world in which children live is not as safe as it should be and physicians share in the responsibility to improve that world for all children.

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